Issued October 21, 1911.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—CIRCULAR No. 42.

MILTON WHITNEY, Chief of Bureau.

SOILS OF THE EASTERN UNITED STATES AND THEIR USE—XX.

THE TRINITY CLAY.

BY

JAY A. BONSTEEL,
Scientist in Soil Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF SOILS.

MILTON WHITNEY, *Chief of Bureau.*
ALBERT G. RICE, *Chief Clerk.*

SCIENTIFIC STAFF.

FRANK K. CAMERON, in charge of Physical and Chemical Investigations.
CURTIS F. MARBUT, in charge of Soil Survey.
OSWALD SCHREINER, in charge of Fertility Investigations.

SOILS OF THE EASTERN UNITED STATES AND THEIR USE—XX.

THE TRINITY CLAY.

GEOGRAPHICAL DISTRIBUTION.

The Trinity clay is an alluvial soil occupying large portions of the river bottoms of all of the principal streams which flow through and out from the Cretaceous prairie areas of Alabama, Mississippi, and Texas. The materials from which this alluvial soil is formed are derived by erosion from the black Cretaceous prairie uplands, and are carried down to the main stream channels to be redeposited as alluvial bottom lands along their courses not only within the region of the prairies themselves, but also, in the case of the larger streams, for considerable distances seaward. The Trinity clay is thus found only in the three States mentioned, and it is doubtful if any large areas will be encountered in other States. Within these limits, however, the type is widely distributed, having been encountered in over 20 different soil surveys to an aggregate amount of 570,434 acres.

CHARACTERISTICS OF SOIL AND SUBSOIL.

The coloration of the surface soil of the Trinity clay varies only to a limited degree between dark brown or drab on the one hand, and almost jet black on the other. The surface soil has a depth ranging from 6 to 15 inches with an average of about 10 inches. It usually grades downward through a slightly lighter colored zone into a drab, brownish-yellow, or gray clay subsoil which is characteristically many feet in thickness, especially along the major streams. When wet the surface soil is plastic and sticky, but as it becomes dry it not infrequently sun-cracks and granulates to a considerable degree. The subsoil is invariably waxy and plastic. Both the surface soil and the subsoil are unusually stiff and impervious clays even among the many heavy clay soils encountered in the alluvial bottoms of the various rivers of the United States. Large numbers of mechanical analyses of the subsoil of the Trinity clay have shown a clay content ranging from 35 per cent to 69 per cent, with numerous instances where more than one-half of all of the subsoil material consisted of this very finely divided and plastic constituent. Very little material coarser than silt is ever present.

The Trinity clay could only be confused with the Wabash clay among the alluvial bottom-land types, as these two are the most important dark-colored alluvial clays. The Trinity clay, however, is invariably associated with deposition of sediments derived from the black Cretaceous prairies, while the Wabash clay is confined to the drainage system of the Misisssippi River, and is derived from the brown or black loessial upland prairie soils. The Trinity clay also possesses the distinguishing characteristic of containing lime concretions and nodules in the subsoil. Chemical analyses of the subsoil have shown from 3 to 35 per cent of calcium carbonate in the numerous samples which have been examined.

SURFACE FEATURES AND DRAINAGE.

The Trinity clay resembles the majority of other alluvial soils in that its surface configuration is almost absolutely level and relieved only by those minor changes in elevation due to the existence of low ridges and bars lying parallel with the course of the principal stream along which the type occurs and of intervening depressions, sloughs, or bayous which mark old stream channels.

The altitude at which the Trinity clay is found varies considerably with the elevation of the streams which it adjoins. In Mississippi and in Alabama practically all of the type is found at an elevation ranging from 150 to 400 feet above tide level, while in Texas the altitude ranges from 5 or 10 feet to 500 feet above sea level. In all cases the surface of the type is only slightly elevated above the normal water level of the stream which it adjoins. This elevation ranges from 5 or 6 feet in the minimum instances to an elevation not exceeding 15 to 20 feet in extreme cases. Almost invariably the Trinity clay occupies the first bottoms, although in some areas in northern Texas it is found developed upon older second bottoms at somewhat higher altitudes. As a result of its close association with the stream drainages and of its practically level surface, the natural drainage conditions over the Trinity clay are almost universally poor. It is only upon the higher ridges and upon limited areas of the second bottoms that natural drainage conditions are adequate. In practically all other areas artificial drainage must be installed, either through the opening of more direct stream channels or through the drainage of portions of the type into the deeper sloughs and bayous by means of open ditches. Considerable areas of the Trinity clay have thus been reclaimed and brought under cultivation.

In addition to defective drainage the greater part of the type in all areas where it occurs is annually subject to overflows at the time of the spring freshets. A few areas of considerable agricultural importance escape this overflow. Very few areas thus far encoun-

tered in the soil survey work have received any systematic protection through the construction of levees or embankments to shut out the spring floods.

The Trinity clay is very little subject to erosion, the principal damage being done along the convex bends where the larger streams occasionally cut into their banks disastrously. Over the surface of the type the slopes are so gentle that deposition rather than erosion takes place at the time of high water and of abundant rainfall.

LIMITATIONS IN USE.

The Trinity clay, because of its fine-grained texture and dense structure, is not well suited to the production of any except the staple crops of the regions where it occurs. It is recognized universally as a strong productive soil for the growing of cotton and of corn, and in areas where it is naturally or artificially protected from overflow it is also suited to the growing of alfalfa. These are the dominant crops over the entire tilled area of the Trinity clay.

The organic-matter content of the surface soil is unusually high, both because of the character of the original material and because of its mode of deposition as a stream sediment frequently laid down in small quantities over and among the remnants of previously existing vegetation.

Probably one of the greatest difficulties encountered in the cultivation of the Trinity clay, aside from its liability to overflow, lies in the stiff plastic nature of the soil materials and the difficulties which are experienced in the proper plowing and subsequent tillage of this type. Whenever the soil is plowed with an excess of moisture present in the surface soil the furrow is turned in the form of a continuous unbroken ribbon of clay which subsequent tillage operations are usually unable to reduce to proper seed-bed condition. On the other hand, if the soil is allowed to become too dry before being plowed the furrow consists of a succession of hard clods, which are with difficulty reduced to favorable tilth. If, however, the Trinity clay is plowed when it is at or near the optimum moisture content it is possible to secure a well-granulated, friable seed bed, which is easily kept in condition during the remainder of the season. It is sometimes difficult to accomplish this proper plowing and preparation of the Trinity clay, owing to the fact that freshets may have remained above the banks of the stream to an unusually late date in the spring, thoroughly saturating both soil and subsoil and preventing the preparation of the land at the proper season for the planting of crops. Under such circumstances fields which otherwise would produce excellent crops, annually, are of necessity left unplanted to any tilled crop and not infrequently grow up to grass and weeds. There is practically no remedy for these conditions

except the thorough embankment of the most desirable tracts lying within the area of the type, coupled with careful attention to the maintenance of open ditches for draining away surplus water of local origin. The Trinity clay occurs almost exclusively in the southern warm temperate region of the United States, and at the lower altitudes. It is, therefore, suited to the production of the crops of that region, chief among which is cotton, with corn of secondary importance and with local areas of sugar cane and rice. These crops are supplemented by the growing of small areas of several other staples, including oats, wheat, sorghum, and an increasing area of alfalfa under the most favorable drainage conditions.

IMPROVEMENT IN SOIL EFFICIENCY.

Embankment and drainage constitute the most necessary improvements in connection with the cultivation of the Trinity clay.

In the soil survey of the Cooper area, Texas, a characteristic description of the Trinity clay is given, and the high agricultural value of this land when properly protected is pointed out. In this connection the author of the report states, "these black clay bottoms follow the creeks across the whole of north Texas and comprise hundreds of thousands of acres of land that ought to be of more economic value than it is at present. In Lamar and Delta Counties strips of the Trinity clay follow the streams throughout the counties and in places attain a width of several miles." The additional fact is noted that the type is only occupied for agricultural purposes to a very limited degree, and that thousands of acres of it are overgrown with hickory, oak, and bois d'arc. Similar descriptions of the Trinity clay may be found in the majority of soil survey reports concerning areas where it occurs. A consideration of the condition of the type throughout the large number of areas in which it has been encountered shows that this extremely valuable and wonderfully fertile soil is little used for crop production. The one difficulty which prevents such usage is the lack of proper protection from overflow.

In the majority of instances it would be extremely difficult for any individual farmer to establish the necessary embankment system for the protection of such a portion of his farm as might lie within the alluvial bottoms. The expense involved, the magnitude of the engineering work and the necessity, in the majority of the cases, for the use of the professional services of an engineer render this form of improvement impossible for the individual. In consequence, in those States where this valuable soil type chiefly occurs it would be desirable that drainage and embankment laws should be so drawn that drainage areas might be formed through the association of a majority of the farmers owning lands which it was desired to protect. Laws of this character have been in successful operation in many of

the central prairie States for a considerable period of time and some of the most valuable corn lands of Ohio, Indiana, and Illinois have been reclaimed from a swampy condition through the operation and under the protection of such laws. Many thousands of acres of the Trinity clay could be reclaimed for the safe and continuous production of crops by cooperation between the State and its interested citizens.

Each particular area for which drainage and embankment are proposed should be considered as an individual engineering unit, and the services of a competent drainage engineer should be secured to determine the feasibility of the work, the cost of the operation, and to apportion that cost equitably under appropriate laws and articles of incorporation over the different areas of land improved. It would be impossible to describe the many features of the engineering problem so that they would be even generally applicable to the different areas which are capable of being reclaimed, but in general it may be said that the Trinity clay can be bought in its undrained and unprotected state at prices ranging from $1 to $10 an acre, and that in the majority of instances the necessary embankments for the diking and drainage of the land could be constructed at a cost not to exceed $15 an acre for an average cost, or $25 an acre over considerable areas in extreme cases. Since areas of this soil which are not subject to inundation at the present time and which have consequently been brought under intensive forms of tillage are held at from $50 to $75 or $80 an acre, it is seen that the margin of profit between the cost of the land and the cost of the improvement, on the one side, and the ultimate value of the land when reclaimed is sufficient to justify the expense of reclamation. The soil is well supplied with organic matter. The vast preponderance of its area is annually subject to surface renewal through the deposition of added sediments from the uplands, and in rare instances only have those farmers tilling the Trinity clay thought that there was any necessity for the application of commercial fertilizers in order to produce satisfactory crops.

LIMITATIONS UPON SPECIAL CROPS.

In general the Trinity clay is not well suited to the production of any special crops. Small acreages of onions have been grown upon this type in some of the more southern areas in Texas, and fair success has been reported. It is not thought, however, that the type is particularly well suited to this crop, since a more silty and friable soil is generally chosen for onion growing. Similarly potatoes and late garden vegetables are locally produced for home use upon an extremely limited acreage of the Trinity clay. While this is desirable

upon the individual plantation or farm, it is not probable that the type should be used to any extent for the production of vegetables or late market garden crops. Other soils better suited to this purpose are usually present upon the uplands and the Trinity clay should, therefore, be omitted from the list of special cropping soils.

In some areas, particularly near the Gulf coast in Texas, the Trinity clay has been used to a limited extent for the production of rice. This use of the type necessitates the building of embankments, not only to keep out flood waters, but also to maintain at a proper level the irrigation waters used in the production of the crop. The soil produces heavy yields of rice, but some difficulty is occasionally experienced under irrigation owing to the stiff, waxy character of the surface soil.

Sugar cane is grown only to a limited extent at present upon the Trinity clay and that in the most southern areas. The type, however, should constitute an admirable soil for the production of cane, being equaled or excelled only by the Wabash clay of the Mississippi drainage system. The extension of sugar-cane production upon the type is to be recommended for the more southern areas.

EXTENT OF OCCUPATION.

It is probable that, taking into consideration all the areas of the Trinity clay which have been encountered in the soil surveys, not over 10 or 15 per cent of the total area mapped is used for the production of farm crops. The remainder of the type consists most frequently of heavily timbered bottom lands, where the oak, ash, elm, pecan, and bois d'arc constitute the principal growth in the more northern regions. In the more southern regions mesquite forms impenetrable thickets upon the Trinity clay. In general there is a fair to rank growth of grass upon the type in the forested areas. Along the southern and western limits of its extent there are not infrequent openings and small prairies in the timbered bottoms. These are usually heavily grass grown and furnish excellent grazing for cattle. Hogs are also extensively grazed upon these bottom-land soils, securing an abundant supply of mast in the autumn. It is only in the northern regions of Texas and in some of the broader bottoms in Alabama and Mississippi that extensive areas of the Trinity clay have been cleared and used for crop production. In almost all instances such areas lie at slightly higher levels than normal or are otherwise naturally protected from any except extreme overflows. A considerable additional area is occasionally tilled when the spring freshets are not particularly high or long continued. Sufficient areas have been occupied in all regions where the Trinity clay occurs to demonstrate thoroughly its unexampled fertility and the desirability of its further occupation for the more intensive forms of

agriculture. It is probable that in the areas of which surveys have been made not less than 350,000 acres of the Trinity clay remain unoccupied by any crop except grass, and that one-half of this total area might easily be occupied for crop production with the expenditure of comparatively small sums for diking and draining.

CROP ADAPTATIONS.

The Trinity clay is one of the best cotton soils in the United States. While it has been occupied only to a limited extent for the production of this crop, the yields secured have been so far above the general averages obtained from the soils of the cotton belt that the Trinity clay ranks among the three or four leading cotton soils of the region. Within the last few years, particularly in the more western regions of its occurrence, some difficulty has been experienced in cotton production upon this soil because of the ravages of the boll weevil. The moist condition, the rank growth of "weed," and the late maturity of the crop have all rendered the cotton grown upon the Trinity clay particularly susceptible to the ravages of the weevil. In this respect it resembles the heavier clay or clay loam soils of practically all of the bottom lands of the Southern States. Before the advent of the boll weevil, when the Trinity clay was properly prepared and properly tilled during the growing season yields of 1 to 1½ bales per acre were frequently secured upon this type. In fact, over extensive tracts planted to cotton the average yield was in excess of three-fourths bale per acre. Even under the difficulties which have more recently been experienced from the ravages of the weevil, average yields of five-eighths to three-fourths of a bale are not infrequently obtained and the type still ranks as an extremely valuable cotton soil. Not only is the quantity produced per acre considerably above the average for the regions where the type occurs, but the staple frequently grades longer than the standard and the cotton thus brings a premium upon the market. As additional experience is gained by the farmers of each community in combating the boll weevil it is probable that the former yields will again be attained and possibly exceeded because of the care in cultivation and the careful selection of varieties and seed which are being adopted under present circumstances.

There are many areas of the Trinity clay upon which cotton has been produced continuously for 20 to 30 years without any appreciable diminution in yield which could be attributed to soil conditions. No fertilizer is used for the production of the crop upon any large acreage of the type. In consequence it may be confidently stated that the hundreds of thousands of acres of Trinity clay which still remain uncleared, unoccupied, and untilled, constitute

an admirable reserve of cotton land which may be brought into occupation at a reasonable cost per acre or per square mile whenever the demand for its use shall become sufficiently great in the different localities where the areas occur.

The Trinity clay is almost equally valuable as a corn soil, although the crop is not produced as extensively in the majority of areas as cotton. Since the advent of the boll weevil, however, increasing acreages of corn are being grown and the Trinity clay bids fair to become one of the leading alluvial bottom corn soils in the Southern States. There are some years when the overflows do not subside at an early enough date to permit the planting of corn. There are other years when the unusually late floods either destroy the plantings of the corn or decrease the yield, but under anything like favorable circumstances the Trinity clay rarely produces less than 35 bushels of corn per acre, and in a large number of instances the yield over considerable areas has been credibly reported at 50 to 60 bushels or even somewhat higher. Thus, the Trinity clay ranks high among southern corn soils and its reclamation and occupation for the production of this crop alone will be fully justified. As in the case of cotton, the use of commercial fertilizers upon the Trinity clay is scarcely required for corn production. Thorough preparation of the land and thorough subsequent tillage constitute the principal needs of the type for corn culture.

Limited areas of oats are also grown upon the Trinity clay, but the largest part of the acreage is usually cut either to be fed green or as hay. In consequence it is difficult to establish the average yield of oats for the type. In the instances where the crop has been thrashed, particularly in the northern Texas areas, yields of 40 to 50 bushels have been secured. Under the warmer climate of the more southern areas it is hardly probable that these yields of grain could be attained.

A small acreage of wheat is occasionally sown upon the Trinity clay in north-central Texas, and yields of 12 to 15 bushels per acre are secured. The use of this type for wheat production is by no means general.

In certain areas where the Trinity clay lies well above the danger from overflow and where the drainage of both surface soil and subsoil are fairly good, alfalfa has been grown to excellent advantage. This crop thrives under the conditions of a deep fertile soil with a calcareous subsoil, and these conditions are exactly fulfilled by well-drained areas of the Trinity clay. In consequence, under favorable conditions, an excellent stand of the crop is secured and yields of 4 to 5 tons of hay per acre are obtained. A considerable part of the alfalfa grown upon the Trinity clay is used for the feeding of work stock or hogs upon the plantations where it is grown. Part of the hay is also baled and sold, bringing prices ranging from $15 to $20

or more a ton. In consequence, areas of the Trinity clay properly situated with regard to overflow and drainage are extremely valuable for alfalfa production, and the acreage of the crop should be considerably increased.

Practically the only other crops grown upon the Trinity clay are limited acreages of rice in the Texas Gulf coast region, and a small amount of sugar cane in the extreme southern portion of the same section. Rice production should probably be extended upon some other type than the Trinity clay, but where the climatic conditions are favorable the type is admirably suited to the production of large yields of sugar cane and the growing of the crop might be considably extended with profit to the grower.

FARM EQUIPMENT.

The farm equipment of the Trinity clay is usually that of the adjoining uplands, since portions of the type are tilled in connection with larger areas of upland soils. In fact, very few farm buildings are erected upon the type owing to its liability to overflow. In general, the light one-mule rig used on the more sandy upland soils is also employed for the breaking and tillage of the Trinity clay. This lightweight outfit is totally inadequate for the proper management of such a heavy, tenacious, plastic soil. In fact, unless the moisture conditions are decidedly favorable it is extremely difficult to break or turn the surface soil with a moldboard plow, and the use of the disk plow and disk cultivator should become much more general upon areas of the Trinity clay. Then if the soil is tilled under favorable moisture conditions the disk machinery is capable of inducing a thoroughly granulated and mellow surface condition, highly favorable to the retention of moisture and to the satisfactory growth of the crop. Where such machinery has been used increased crop yields have not infrequently resulted, and some of the best planters have secured such machinery for use upon the type after experiencing the benefits to be derived from its use upon the upland black prairie soils, which are similar in many respects to the Trinity clay and from which the materials composing the latter type have been derived.

SUMMARY.

The Trinity clay is a black, tenacious, heavy clay found in the alluvial bottom lands of the main streams which flow through the black Cretaceous prairies of Alabama, Mississippi, and Texas and to a considerable distance along the lower courses of such streams as have their headwaters in the prairie sections. Both the surface soil and subsoil are unusually heavy and plastic. The subsoil is marked by a considerable content of calcium carbonate. The sur-

face of the Trinity clay is level to slightly undulating and interrupted only by low alluvial ridges and depressions formed by old bayous and stream courses. The surface of the type is usually from 5 to 15 or 20 feet above the normal water level of the streams which it adjoins. In absolute elevation, the surface of the type ranges from a few feet above sea level to altitudes of about 500 feet along the upper courses of the principal rivers flowing across the Texas Coastal Plain.

The greater proportion of the Trinity clay is subject to annual overflow, and for this reason the type is not extensively used for the production of farm crops. Drainage is also poor over the greater part of the type.

Where natural or artificial protection is provided for the Trinity clay or where the overflows subside early enough in the spring to permit planting, the type is cleared and occupied chiefly for the production of cotton, with a considerable acreage of corn as a secondary crop.

The Trinity clay is competent to produce from three-fourths bale to 1 bale or more of cotton per acre without fertilization. In some areas this yield has been decreased by the ravages of the cotton boll weevil during the past few years, and in such areas increasing acreages of corn are being planted. Even under the conditions brought about by the invasion of the boll weevil, yields of cotton ranging from five-eighths to three-fourths of a bale are still produced upon considerable areas of the Trinity clay.

The Trinity clay takes leading rank as a corn-producing soil in the Southern States, giving yields of 35 to 60 bushels per acre without fertilization.

In properly drained areas, which are also protected from overflow, alfalfa constitutes an important and valuable crop, yielding 4 to 5 tons per acre.

In the Texas Gulf coast country both rice and sugar cane are produced upon the Trinity clay, giving good yields and high acreage returns.

The Trinity clay has little value as a special crop soil, though onions, potatoes, and garden vegetables for home use are not infrequently produced upon it in certain localities.

For the proper protection and reclamation of extensive areas of the Trinity clay, the formation of drainage and embankment districts is essential in order that the community rather than the individual may bear the expense and share the benefits to be derived from such improvements. It is probable that 350,000 acres of the type lying in Alabama, Mississippi, and Texas might profitably be reclaimed if such provision for embankment and drainage could be made. Counting the low cost of the land and the moderate average cost for this form

of improvement, the resultant value of the reclaimed areas has been demonstrated by territory now under cultivation to be about double the expense involved.

Whenever additional areas of cotton land in the South are required the embankment and drainage of the Trinity clay should provide hundreds of thousands of acres of the best cotton land in the alluvial bottoms of the States where the type occurs.

The Trinity clay is stiff, plastic, and difficult to work, and the lightweight animals and machinery usually employed are scarcely adequate for its proper tillage. Heavier work stock and disk machinery are to be recommended for the working of this type.

Approved.

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *July 12, 1911.*

APPENDIX.

The following table shows the extent of the Trinity clay in the areas surveyed to this time.

In the first column is stated the particular survey in which the soil was encountered; in the second column, its extent in acres; and in the third column, the volume of the Field Operations of the Bureau of Soils in which the report upon the area may be found. Those desiring a detailed description of the soil and of the general conditions which surround it in any particular area may consult these volumes in almost any public library.

Areas of Trinity clay encountered in the soil survey.

Survey.	Area of soil.	Year of publication, Field Operations.
Alabama:	*Acres.*	
Hale County	27,456	1909
Montgomery County [1]	50,624	1905
Mississippi:		
Clay County	20,032	1909
Monroe County	27,904	1908
Oktibbeha County [2]	7,616	1907
Texas:		
Anderson County [1]	47,872	1904
Austin area [1]	9,984	1904
Bastrop County [2]	2,432	1907
Brazoria area [3]	133,056	1902
Cooper area [2]	61,248	1907
Corpus Christi area [4]	1,024	1908
Franklin County [2]	6,336	1908
Grayson County	34,176	1909
Houston County [2]	48,768	1905
Morris County	6,528	1909
Robertson County [2]	14,528	1907
San Marcos area [2]	9,920	1906
Titus County	12,032	1909
Waco area [5]	20,738	1905
Wilson County [2]	28,160	1907

[1] Mapped as Yazoo clay.
[2] Mapped as Wabash clay.
[3] Mapped as Sharkey clay
[4] Mapped as Corpus Christi clay.
[5] Mapped as Yazoo clay and Yazoo heavy clay.